Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead

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A.2.8 SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON

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A.2.8.1 Summary of Previous BRT Conclusions

The status of chinook salmon coastwide was formally assessed in 1998 (Myers et al. 1998); however, NMFS had previously recognized Sacramento River winter-run chinook as a "distinct population segment" under the ESA (NMFS 1987).

Summary of major risk factors and status indicators

Historically, winter-run chinook salmon were dependent on access to spring-fed tributaries to the upper Sacramento River that stayed cool during the summer and early fall. Adults enter freshwater in early winter and spawn in the spring and summer. Juveniles rear near the spawning location until at least the fall, when water temperatures in lower reaches are suitable for migration. Winter-run chinook salmon were abundant and comprised populations in the McCloud, Pit, and Little Sacramento, with perhaps smaller populations in Battle Creek and the Calaveras River. On the basis of commercial fishery landings in the 1870s, Fisher (1994) estimated that the total run size of winter-run chinook salmon may have been 200,000 fish.

The most obvious challenge to winter-run chinook salmon was the construction of Shasta Dam, which blocked access to the entire historic spawning habitat. It was not expected that winter-run chinook salmon would survive this habitat alteration (Moffett 1949). Cold-water releases from Shasta, however, created conditions suitable for winter-run chinook salmon for roughly 100 km downstream from the dam. Presumably, there were several independent populations of winter-run chinook salmon in the Pitt, McCloud, and Little Sacramento Rivers, and various tributaries to these rivers, such as Hat Creek and the Fall River. These populations merged to form the present single population. If there ever were populations in Battle Creek and the Calaveras River, they have been extirpated.

In addition to having only a single extant population dependent on artificially created conditions, winter-run chinook salmon face numerous other threats. Chief among these is small population size—escapement fell below 200 fish in the 1990s. Population size declined monotonically from highs of near 100,000 fish in the late 1960s, indicating a sustained period of poor survival. There are questions of genetic integrity due to winter-run chinook salmon having passed through several bottlenecks in the 20th century. Other threats include inadequately screened water diversions, predation at artificial structures and by non-native species, pollution from Iron Mountain Mine (among other sources), adverse flow conditions, high summer water temperatures, unsustainable harvest rates, passage problems at various structures (e.g., Red Bluff Diversion Dam), and vulnerability to drought.

Previous BRT conclusions

The chinook salmon BRT spent little time considering the status of winter-run chinook salmon, because winter-run chinook salmon were already listed as endangered at the time of previous BRT meetings.

Listing status

Winter-run chinook salmon were listed as Threatened in 1990 and reclassified as Endangered 1994.

A.2.8.2 New Data and Updated Analyses

Viability assessments

Two studies have been done on the population viability of Sacramento River winter-run chinook salmon. Botsford and Brittnacher (1998), in a paper that is part of the draft recovery plan, developed de-listing criteria using a simple age-structured, density-independent model of spawning escapement. They concluded, on the basis of the 1967-1995 data, that winter-run chinook salmon were certain to fall below the quasi-extinction threshold of three consecutive spawning runs with less than 50 females.

Lindley and Mohr (2003) developed a slightly more complex Bayesian model of winter-run chinook salmon spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures initiated in 1989. This model, due to its allowance for the growth rate change, its accounting for parameter uncertainty, and use of newer data (through 1998), suggested a lower but still biologically significant expected quasi-extinction probability of 28%.

Draft recovery plan

The draft recovery plan for winter-run chinook salmon (NMFS 1997) provides a comprehensive review of the status, life history, habitat requirements, and risk factors of winter-run chinook salmon. It also provides a recovery goal: an average of 10,000 females spawners per year and a $\lambda \geq 1.0$ calculated over 13 years of data (assuming a certain level of precision in spawning escapement estimates).

New abundance data

The winter-run chinook salmon spawning run has been counted at Red Bluff Diversion Dam (RBDD) fish ladders since 1967. Escapement has been estimated with a carcass survey since 1996. Through the mid-1980s, the RBDD counts were very reliable. At that time, changes to the dam operation were made to alleviate juvenile and adult passage problems. Now, only the tail end of the run (about 15% on average) is forced over the ladders, greatly reducing the accuracy of the RBDD counts. The carcass mark-recapture surveys were initiated to improve escapement estimates. The two measures are in very rough agreement, and there are substantial problems with both estimates, making it difficult to choose one as more reliable than the other. One problem with the carcass-based estimate is the estimation of the probability of capturing carcasses—it appears that the probability of initial carcass recovery depends strongly on the sex of the fish, the size of the fish, and possibly on whether it has been previously recovered. In the winter-run chinook salmon carcass surveys, a high ratio of female to males is observed (e.g., Snider et al. 1999), and several studies of salmon carcass recovery have noted that females are recovered with a higher probability than males, presumably because of the different behavior of males and females (e.g., Shardlow et al. 1986 and references therein). In spite of these problems, both abundance measures suggest that the abundance of winter-run chinook salmon is increasing. Based on the RBDD counts, the winter-run chinook salmon population has been growing rapidly since the early 1990s (Figure A.2.8.1), with a short-term trend of 0.26 (Table A.2.8.1). On the population growth rate-population size space, the winter-run chinook salmon population has a somewhat low population growth and moderate size compared to other Central Valley salmonid populations (Figure A.2.8.2).

Table A.2.8.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals. Results for other populations are shown for comparison.

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sacramento River winter-run chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Creek spring-run chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Creek spring-run chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Creek spring-run chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)
Sacramento River steelhead	1,952	1,425	12,320	0.95 (0.90, 1.02)	-0.07 (-0.13, 0.00)	-0.09 (-0.13, -0.06)	NA

Winter-run chinook salmon may be responding to a number of factors, including wetter-than-normal winters, changes in ocean harvest regulations since 1995 significantly reducing harvest, changes in RBDD operation, improved temperature management on the Upper Sacramento (including installation of a cold-water release device on Shasta Dam), water quality improvements due to remediation of Iron Mountain Mine discharges, changes in operations of the state and federal water projects, and a variety of other habitat improvements. While the status of winter-run chinook salmon is improving, there is only one winter-run chinook salmon population and it is dependent on cold-water releases of Shasta Dam, which could be vulnerable to a prolonged drought. The recent 5-year geometric mean is only 3% of the maximum post-1967 5-year geometric mean.

The RBDD counts are suitable for modeling as a random-walk-with-drift (also known as the "Dennis model" [Dennis et al. 1991]). In the RWWD model, population growth is described by exponential growth or decline:

$$N_{t+1} = N_t \exp(\mu + \eta_t), \quad (1)$$

where N_t is the population size at time t, μ is the mean population growth rate, and η_t is a normal random variable with mean=0 and variance = σ^2_p.

Table A.2.8.2. Parameter estimates for the constant-growth and step-change models applied to winter-run chinook salmon. Numbers in parentheses indicate 90% confidence intervals.

	Model	
parameter	**constant μ**	**step change μ**
μ	-0.085	-0.214
	(-0.181, 0.016)	(-0.322, -0.113)
δ	NA	0.389
	NA	(0.210, 0.574)
σ^2_p	0.105	0.056
	(0.094, 0.122)	(0.046, 0.091)
σ^2_m	0.0025	0.011
	(2.45E-6, 0.0126)	(3.92E-6, 0.022)
P_{100}(ext)[a]	0.40	0.003
	(0.00, 0.99)	(0.0, 0.0)

[a] Probability of extinction (pop. size < 1 fish) within 100 years.

The RWWD model, as written in Equation 1, ignores measurement error. Observations (y_t) can be modeled separately,

$$y_t = N_t \exp(\varepsilon_t), \quad (2)$$

where ε_t is a normal random variable with mean = 0 and variance = σ^2_m. Equations 1 and 2 together define a state-space model that, after linearizing by taking logarithms, can be estimated using the Kalman filter (Lindley in press).

A recent analysis of the RBDD data (Lindley and Mohr 2003) indicated that the population growth since 1989 was higher than in the preceding period. For this reason, I fit two forms of the RWWD model—one with a fixed growth rate (constant-growth model) and another with a growth rate with a step-change in 1989, when conservation actions began (step-change model, $\mu_t = \mu$ for $t < 1989$, $\mu_t = \mu + \delta$ for $t \geq 1989$). In both cases, a 4-year running sum was applied to the spawning escapement data to form a total population estimate (Holmes 2001). Results of model fitting are shown in Table A.2.8.2. The constant-growth model satisfies all model diagnostics, although visual inspection of the residuals shows a strong tendency to under-predict abundance in the most recent 10 years. The residuals of the step-change model fail the Shapiro-Wilks test for normality; the residuals look truncated on the positive side, meaning that good years are not as extreme as bad years. Winter-run chinook salmon growth rate might be better modeled as a mixture between a normal distribution and another distribution reflecting near-catastrophic population declines caused by episodic droughts.

According to Akaike's information criterion (AIC), the step-change model is a much better approximation to the data than the constant population growth rate model, with an AIC difference of 9.61 between the two models (indicating that the data provide almost no support for the constant-growth model). The step-change model suggests the winter-run chinook salmon population currently has a λ of 1.21, while for the constant population growth rate model, λ = 0.97[5]. The extinction risks predicted by the two models are extremely different: winter-run chinook salmon have almost no risk of extinction if the apparent recent increase in λ holds in the future, but are certain to go extinct if the population grows at its average rate, with a most likely time of extinction being 100 years. While it would be dangerous to assume that recent population growth will hold indefinitely, it does appear that the status of winter-run chinook salmon is improving.

Harvest impacts

Substantial changes in ocean fisheries off central and northern California have occurred since the last status review (PFMC 2002a, b). Ocean harvest rate of winter-run chinook salmon is thought to be a function of the Central Valley chinook salmon ocean harvest index (CVI), which is defined as the ratio of ocean catch south of Point Arena to the sum of this catch and the escapement of chinook salmon to Central Valley streams and hatcheries. Note that other stocks (e.g., Klamath chinook salmon) contribute to the catch south of Point Arena, and that fish from the Central Valley are caught in Oregon fisheries. This harvest index ranged from 0.55 to nearly 0.80 from 1970 to 1995, when harvest regimes were adjusted to protect winter-run chinook salmon.. In 2001, the CVI fell to 0.27. The reduction in harvest is presumably at least partly responsible for the record spawning escapement of fall-run chinook salmon ($\approx$ 540,000 fish in 2001) and concurrent increases in other chinook salmon runs in the Central Valley.

Because they mature before the ocean fishing season, winter-run chinook salmon should have lower harvest rates than fall-run chinook salmon, if they have similar age-at-maturity. At the time of the last status review, the only information on the harvest rate of winter-run chinook salmon came from a study conducted in the 1970s. Hallock and Fisher (1985) reported that the average catch/(catch+escapement) for the 1969-71 broodyears was 0.40 for the ocean fishery. For the 1968-1975 period, freshwater sport fisheries caught an average of 10% of the winter chinook salmon run.

The recent release of significant numbers of ad-clipped winter-run chinook salmon provides new, but limited, information on the harvest of winter-run chinook salmon in coastal recreational and troll fisheries. The Pacific Fisheries Management Council's Sacramento River Winter and Spring Chinook salmon Workgroup (SRWSCW) conducted a cohort reconstruction of the 1998 broodyear (PFMC 2003). Winter-run chinook salmon are mainly vulnerable to ocean fisheries as 3-year olds. SRWSCW calculated, on the basis of 123 coded-wire-tag

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[5]In this section of the document, λ is defined as $\exp(\mu + \sigma^2_p / 2)$, the *mean* annual population growth rate.

recoveries, that the ocean fishery impact rate on 3-year-olds was 0.23, and the in-river sport fishery impact rate was 0.24. These impacts combine to reduce escapement to 100*(1-0.23)*(1-0.24) = 59% of what it would have been in the absence of fisheries, assuming no natural mortality during the fishing season. The high estimated rate of harvest in the river sport fishery, which arises from the recovery of eight coded-wire tags, was a surprise because salmon fishing is closed from January 15 to July 31 to protect winter-run chinook salmon. The tags were recovered in late December/early January, at the tail end of the fishery for late-fall-run chinook salmon.. The estimate of river sport fishery impact is much less certain than the ocean fishery impact estimate because of the lower number of tag recoveries, less rigorous tag sampling, and larger expansion factors. The California Fish and Game Commission is moving forward with an emergency action to amend sport fishing regulations to ban retention of salmon caught in river sport fisheries on January 1 rather than January 15. Had such regulations been in place in 1999/2000, the freshwater harvest rate would have been 20% of that observed.

New hatchery information

Livingston Stone National Fish Hatchery (LSNFH) was constructed at the base of Shasta Dam in 1997, with the sole purpose of helping to restore natural production of winter-run chinook salmon. LSNFH was designed as a conservation hatchery with features intended to overcome the problems of CNFH (better summer water quality, natal water source). All production is ad-clipped. Each individual considered for use as broodstock is genotyped to ensure that it is a winter-run chinook salmon. No more than 10% of the broodstock is composed of hatchery-origin fish, and no more than 15% of the run is taken for broodstock, with a maximum of 120 fish. Figure 3 shows the number of winter-run chinook salmon released by CNFH/LSNFH; Figure 4 shows the number of winter-run chinook salmon spawners taken into the hatchery.

A.2.8.3 New Comments

The California State Water Contractors, the San Luis and Delta-Mendota Water Authority, and the Westlands Water District recommend that the listing status of winter-run chinook salmon be changed from Endangered to Threatened. They base this proposal on the recent upturn of adult abundance, recently initiated conservation actions (restoration of Battle Creek, ocean harvest reductions, screening of water diversions, remediation of Iron Mountain Mine, and improved temperature control), and a putative shift in ocean climate in 1999.

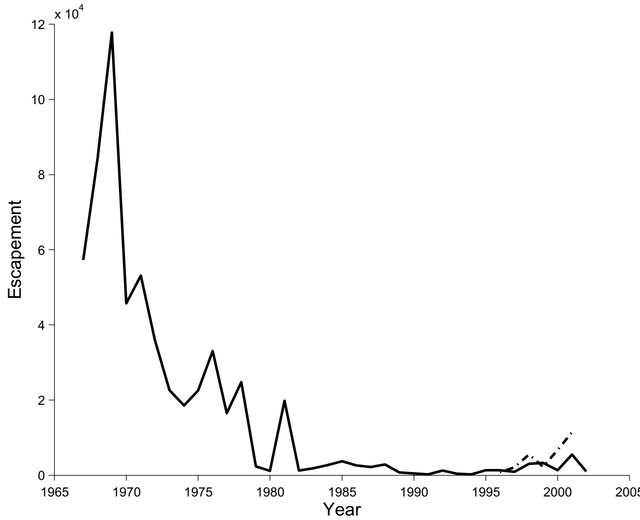

Figure A.2.8.1. Estimated winter-run chinook spawner abundance as determined by RBDD fish ladder (solid line) and carcass mark-recapture (dashed line).

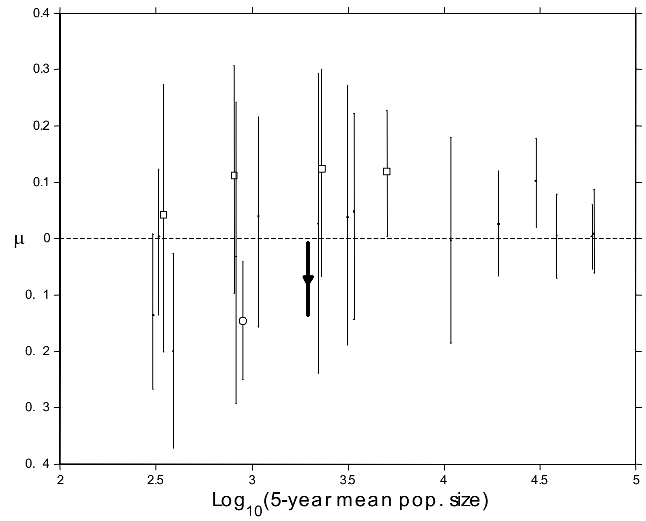

Figure A.2.8.2. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; open squares- spring chinook; filled triangle- winter-run chinook; small black dots- other chinook stocks. Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, μ ≈ log(λ).)

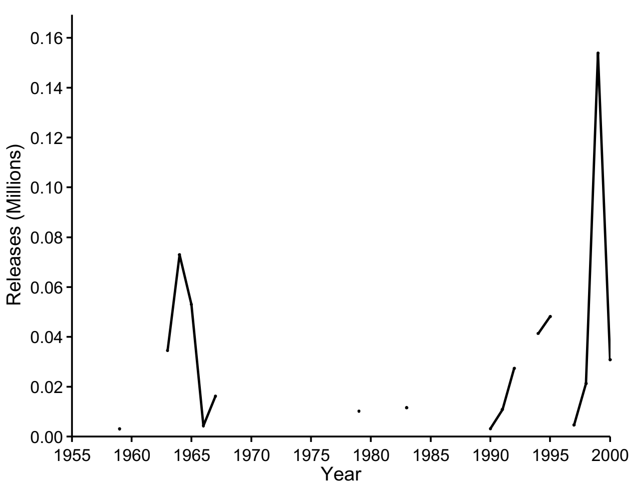

Figure A.2.8.3. Number of juvenile winter-run chinook released by Coleman and Livingston Stone National Fish Hatcheries.

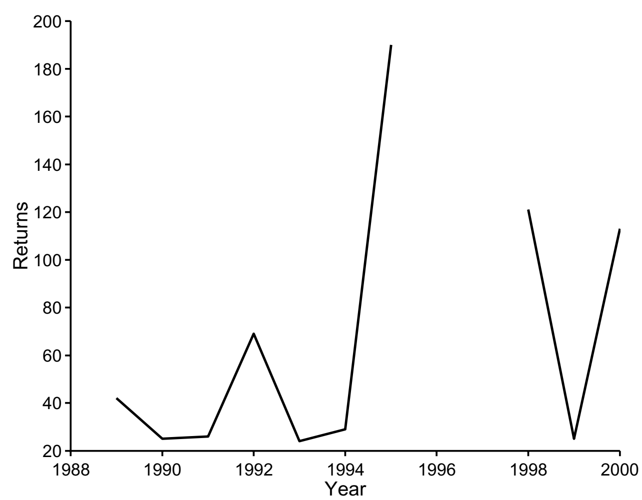

Figure A.2.8.4. Number of adult winter-run chinook collected for broodstock by Coleman and Livingston Stone National Fish Hatcheries.

A.3 CHINOOK SALMON BRT CONCLUSIONS

Snake River fall-run chinook salmon ESU

A majority (60%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). This represented a somewhat more optimistic assessment of the status of this ESU than was the case at the time of the original status review, when the BRT concluded that Snake River fall-run chinook salmon "face a substantial risk of extinction if present conditions continue" (Waples et al. 1991). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.0 for growth rate/productivity to 3.6 for spatial structure (Table A.3.2).

On the positive side, the number of natural origin spawners in 2001 was well in excess of 1000 for the first time since counts at Lower Granite Dam began in 1975. Management actions have reduced (but not eliminated) the fraction of fish passing Lower Granite Dam that are strays from out-of-ESU hatchery programs. Returns in the last two years also reflect an increasing contribution from supplementation programs based on the native Lyons Ferry Broodstock. With the exception of the increase in 2001, the ESU has fluctuated between approximately 500-1000 adults, suggesting a somewhat higher degree of stability in growth rate and trends than is seen in many other salmon populations.

In spite of the recent increases, however, the recent geometric mean number of naturally produced spawners is still less than 1000, a very low number for an entire ESU. Because of the large fraction of naturally spawning hatchery fish, it is difficult to assess the productivity of the natural population. The relatively high risk matrix scores for spatial structure and diversity (3.5-3.6) reflect the concerns of the BRT that a large fraction of historic habitat for this ESU is inaccessible, diversity associated with those populations has been lost, the single remaining population is vulnerable to variable environmental conditions or catastrophes, and continuing immigration from outside the ESU at levels that are higher than occurred historically. Some BRT members were concerned that the efforts to remove stray, out-of-ESU hatchery fish only occur at Lower Granite Dam, well upstream of the geographic boundary of this ESU. Specific concerns are that natural spawners in lower river areas will be heavily affected by strays from Columbia River hatchery programs, and that this approach effectively removes the natural buffer zone between the Snake River ESU and Columbia River ocean-type chinook salmon. The effects of these factors on ESU viability are not known, as the extent of natural spawning in areas below Lower Granite Dam is not well understood, except in the lower Tucannon River.

Snake River spring/summer-run chinook salmon ESU

About two-thirds (68%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). As indicated by mean risk matrix scores, the BRT had much higher concerns about abundance (3.6) and growth rate/productivity (3.5) than for spatial structure (2.2) and diversity (2.3) (Table A.3.2).

Although there are concerns about loss of an unquantified number of spawning aggregations that historically may have provided connectivity between headwater populations, natural spawning in this ESU still occurs in a wide range of locations and habitat types.

Like many others, this ESU saw a large increase in escapement in many (but not all) populations in 2001. The BRT considered this an encouraging sign, particularly given the record low returns seen in many of these populations in the mid 1990s. However, recent abundance in this ESU is still short of the levels that the proposed recovery plan for Snake River salmon indicated should be met over at least an eight year period (NMFS 1995). The BRT considered it a positive sign that the non-native Rapid River broodstock has been phased out of the Grande Ronde system, but the relatively high level of both production/mitigation and supplementation hatcheries in this ESU leads to ongoing risks to natural populations and makes it difficult to assess trends in natural productivity and growth rate.

Upper Columbia River spring-run chinook salmon ESU

Assessments by the BRT of the overall risks faced by this ESU were divided, with a slight majority (53%) of the votes being cast in the “danger of extinction” category and a substantial minority (45%) in the “likely to be endangered” category (Table A.3.1). The mean risk matrix scores reflect strong ongoing concerns regarding abundance (4.4) and growth rate/productivity (4.5) in this ESU and somewhat less (but still significant) concerns for spatial structure (2.9) and diversity (3.5) (Table A.3.2).

Many populations in this ESU have rebounded somewhat from the critically low levels that immediately preceded the last status review evaluation, and this was reflected in the substantial minority of BRT votes cast that were not cast in the “danger of extinction” category. Although this was considered an encouraging sign by the BRT, the last year or two of higher returns come on the heels of a decade or more of steep declines to all time record low escapements. In addition, this ESU continues to have a very large influence by hatchery production, both from production/mitigation and supplementation programs. The extreme management measures taken in an effort to maintain populations in this ESU during some years in the late 1990s (collecting all adults from major basins at downstream dams) are a strong indication of the ongoing risks to this ESU, although the associated hatchery programs may ultimately play a role in helping to restore self-sustaining natural populations.

Lower Columbia River chinook salmon ESU

A majority (71%) of the BRT votes for this ESU fell in the “likely to become endangered” category, with minorities falling in the “danger of extinction” and “not likely to become endangered” categories (Table A.3.1). Moderately high concerns for all VSP elements are indicated by mean risk matrix scores ranging from 3.2 for abundance to 3.9 for diversity (Table A.3.2).

All of the risk factors identified in previous reviews were still considered important by the BRT. The Willamette/Lower Columbia River TRT has estimated that 8-10 historic populations in this ESU have been extirpated, most of them spring-run populations. Near loss of that important life history type remains in important BRT concern. Although some natural production currently occurs in 20 or so populations, only one exceeds 1000 spawners. High hatchery production continues to pose genetic and ecological risks to natural populations and to mask their performance. Most populations in this ESU have not seen as pronounced increases in recent years as occurred in many other geographic areas.

Upper Willamette River chinook salmon ESU

A majority (70%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). The BRT found moderately high risks in all VSP elements (mean risk matrix scores ranged from 3.1 for growth rate/productivity to 3.6 for spatial structure) (Table A.3.2).

Although the number of adult spring-run chinook salmon crossing Willamette Falls is in the same range (about 20,000–70,000) it has been for the last 50 years, a large fraction of these are hatchery produced. The score for spatial structure reflects concern by the BRT that perhaps a third of the historic habitat used by fish in this ESU is currently inaccessible behind dams, and the BRT remained concerned that natural production in this ESU is restricted to a very few areas. Increases in the last 3-4 years in natural production in the largest remaining population (the McKenzie) were considered encouraging by the BRT. With the relatively large incidence of hatchery fish, it is difficult to determine trends in natural production.

Puget Sound chinook salmon ESU

A majority (74%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 2.9 for spatial structure to 3.6 for growth rate/productivity (Table A.3.2).

Most population indices for this ESU have not changed substantially since the last BRT assessment. The Puget Sound TRT has identified approximately 31 historic populations, of which 9 are believed to be extinct, with most of the populations that have been lost being early run. Other concerns noted by the BRT are the concentration of the majority of natural production in just two basins, high levels of hatchery production in many areas of the ESU, and widespread loss of estuary and lower floodplain habitat diversity (and, likely, associated life history types). Although populations in this ESU have not experienced the sharp increases in the last 2-3 years seen in many other ESUs, more populations increased than decreased over the 4 years since the last BRT assessment. After adjusting for changes in harvest rates, however, trends in productivity are less favorable. Most populations are relatively small, and recent natural production within the ESU is only a fraction of estimated historic run size. On the positive side, harvest rates for all populations have been reduced from their peaks in the 1980s, and some hatchery reforms have been implemented (e.g., elimination of many net pen programs that were leading to widespread straying, and transition of other programs to more local broodstocks). The BRT felt that these management changes should help facilitate recovery if other limiting factors (especially habitat degradation) are also addressed. The BRT felt that the large recovery effort organized around the Puget Sound Shared Strategy was a positive step because it could help to link and coordinate efforts in many separate, local watersheds.

California Coastal chinook salmon ESU

A majority (67%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with votes falling in the "danger of extinction" category outnumbering those in "not warranted" category by nearly 2-to-1 (Table A.3.1). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.1 for diversity to 3.9 for abundance (Table A.3.2).

The BRT was concerned by continued evidence of low population sizes relative to historical abundance and mixed trends in the few time series of abundance indices available for analysis, and by the low abundances and potential extirpations of populations in the southern part of the ESU. The BRT's concerns regarding genetic integrity of this ESU were moderate or low relative to similar issues for other ESUs because 1) hatchery production in this ESU is on a minor scale, and 2) current hatchery programs are largely focused on supplementing and restoring local populations. However, the BRT did have concerns with respect to diversity that were based largely on the loss of spring-run chinook salmon in the Eel River basin and elsewhere in the ESU, and to a lesser degree on the potential loss of diversity concurrent with low abundance or extirpation of populations in the southern portion of the ESU. Overall, the BRT was strongly concerned by the paucity of information and resultant uncertainty associated with estimates of abundance, natural productivity and distribution of chinook salmon in this ESU.

Sacramento River winter-run chinook salmon ESU

A majority (60%) of the BRT votes fell into the "in danger of extinction" category, with a minority (38%) voting for the "likely to become endangered" and only 2% voting for "not warranted." (Table A.3.1). The main VSP concerns were in the spatial structure and diversity categories (4.8 and 4.2, respectively), although there was significant concern in the abundance and productivity categories (3.7 and 3.5, respectively) (Table A.3.2).

The main concerns of the BRT relate to the lack of diversity within this ESU. The BRT was very troubled by the fact that this ESU is represented by a single population that has been displaced from its historic spawning habitat into an artificial habitat created and maintained by a dam. The BRT presumed that several independent populations of winter-run chinook salmon were merged into a single population, with the potential for a significant loss of life history and genetic diversity. Furthermore, the population has passed through at least two recent bottlenecks—one when Shasta Dam was filled and another in the late 1980s-early 1990s—that probably further reduced genetic diversity. The population has been removed from the environment where it evolved, dimming its long-term prospects for survival. The BRT was modestly heartened by the increase in abundance since the lows of the late 1980s and early 1990s.

Central Valley spring-run chinook salmon ESU

A large majority (69%) of the BRT votes fell into the “likely to become endangered” category, with a minority (27%) of votes going to “in danger of extinction” and 4% “not warranted” (Table A.3.1). There was roughly equal concern about abundance, spatial structure and diversity (3.5-3.8), and less concern about productivity (2.8) (Table A.3.2).

A major concern of the BRT was the loss of diversity caused by the extirpation of spring-run chinook salmon populations from most of the Central Valley, including all San Joaquin tributaries. The only populations left in the Sierra Nevada ecoregion are supported by the Feather River hatchery. Another major concern of the BRT was the small number and location of extant spring-run chinook salmon populations-- only three streams, originating in the southern Cascades, support self-sustaining runs of spring-run chinook salmon, and these three streams are close together, increasing their vulnerability to catastrophe. Two of the three extant populations are fairly small, and all were recently quite small. The BRT was also concerned about the Feather River spring-run chinook salmon hatchery population, which is not in the ESU but does produce fish that potentially could interact with other spring-run chinook salmon populations, especially given the off-site release of the production.

Table A.3.1. Tally of FEMAT vote distribution regarding the status of 9 chinook salmon ESUs reviewed by the chinook salmon BRT. Each of 15 BRT members allocated 10 points among the three status categories.

ESU	At Risk of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Snake River fall-run	38	91	21
Snake River spring/summer-run	30	102	18
Upper Columbia River spring-run	79	67	4
Puget Sound	12	111	27
Lower Columbia River	25	107	18
Upper Willamette River	32	105	13
California Coastal[1]	36	100	13
Sacramento River winter-run[2]	78	49	3
CA Central Valley spring-run[2]	35	90	5

[1] One BRT member assigned 9 points [2] Votes tallied for 13 BRT members

Table A.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 9 chinook salmon ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Snake River fall-run	3.4 (2-5)	3.0 (2-5)	3.6 (2-5)	3.5 (2-5)
Snake River spring/summer-run	3.6 (2-5)	3.5 (3-5)	2.2 (1-3)	2.3 (1-3)
Upper Columbia River spring-run	4.4 (3-5)	4.5 (3-5)	2.9 (2-4)	3.5 (2-5)
Puget Sound	3.3 (2-4)	3.6 (3-4)	2.9 (2-4)	3.2 (2-4)
Lower Columbia River	3.2 (2-4)	3.7 (3-5)	3.5 (3-4)	3.9 (3-5)
Upper Willamette River	3.7 (2-5)	3.1 (2-5)	3.6 (3-4)	3.2 (2-4)
California Coastal[1]	3.9 (3-5)	3.3 (3-4)	3.2 (2-4)	3.1 (2-4)
Sacramento River winter-run[2]	3.7 (3-5)	3.5 (2-5)	4.8 (4-5)	4.2 (3-5)
CA Central Valley spring-run[2]	3.5 (3-4)	2.8 (2-4)	3.8 (3-5)	3.8 (3-5)

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